




4) I was informed of the decision made to prepare and file a patent application by UNITED TECHNOLOGIES CORPORATION on October 27, 2003. A first draft was forwarded to the inventors for review on November 7, 2003. An updated draft with revisions suggested by the inventors was forwarded for further review on November 12, 2003. The assignment and declaration were signed by the inventors on January 8, 2004 and January 2, 2004, respectively. Diligence was maintained throughout the preparation and filing of the application. The subject application was filed on January 20, 2004.

5) With regard to the 325°F temperature limit, communications with the inventors has indicated that this is a well known fuel temperature limit as operations above approximately 325°F produce coking. This understanding is further recited in paragraph 21 of the specification which recites "the optimized high temperature ester-based oil combined with the deoxygenated fuel temperature thermal retention capabilities permits associated components to operate above the *conventional* 325°F temperature limit." [Emphasis added.]

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated: May 4, 2007

  
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DAVID L. WISZ

# Integrated FSU and Aircraft Thermal Management System with an optimal-ester based oil

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## BACKGROUND

Aircraft Thermal Management Systems (TMS) provide temperature control of flight critical components by employing the fuel flow to the combustor as a heat sink. However, the heat capacity of aviation fuel is limited by a coking temperature limit, above which coke deposits form, resulting in a progressive degradation of engine performance. To avoid this coking condition, the thermal management system often employs supplemental heat exchangers that reject heat to either ambient or engine fan bypass air flow. This method removes heat from the engine cycle and thus reduces engine efficiency as well as introduces additional weight in the form of air/liquid heat exchangers.

## INVENTION

The Fuel Stabilization Unit (FSU), allows the fuel to remain stable at much higher temperatures without coking by deoxygenating the fuel, enabling higher temperature loads to reject their heat to the fuel. Although the exploitable heat sink (maximum operating temperature) can be increased by the FSU, the cooled components must also be able to survive at higher temperatures. In this embodiment this is accomplished by coupling the FSU with a high-temperature lubrication oil (e.g. optimal-ester based oil). This allows components to reject heat exclusively to the fuel and survive. This embodiment eliminates the additional weight and performance penalty of air/liquid heat exchangers as well as improves engine performance by capturing waste heat in the engine cycle.

Figure 1 shows a traditional TMS schematic for a geared turbofan that rejects heat from various heat loads, including main bearing and fan drive gear system, to the fuel. In this case, the heat to be rejected is greater than the capacity of the fuel and therefore requires additional cooling via heat exchangers that reject heat to the engine fan by-pass duct..

Figure 2 shows a schematic for an example TMS design that includes an FSU to allow the fuel to exceed the traditional coking temperatures. Potentially, no additional air heat exchangers are required and all of the heat generated by the system components can be rejected to the fuel. In order to utilize the high temperature fuel heat sink, the heat loads must also be a sufficiently high temperature to provide adequate heat transfer to the fuel (and survive at those temperatures). Therefore, the new system includes high temperature oil that allows the engine oil-loop (shown in Figure 2) to exceed current oil temperature limits and achieve a temperature high enough to efficiently reject heat to the fuel. The location of the FSU in the diagram represents only one of many possible locations. For example the FSU could be located between the generator and fan gear heat exchangers or downstream of the main fuel pump centrifugal stage.

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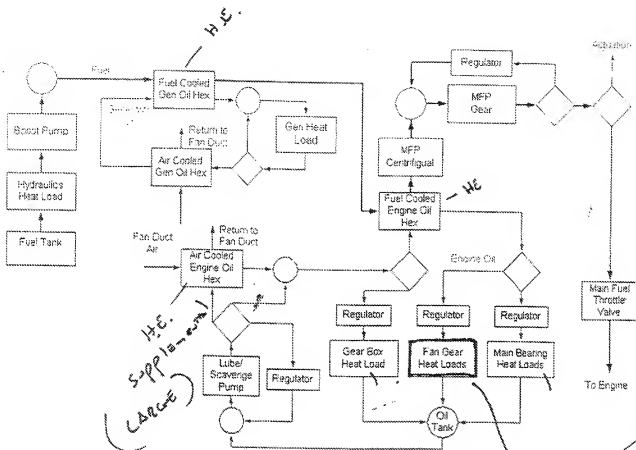


Figure 1: Conventional thermal management system for geared turbofan engine

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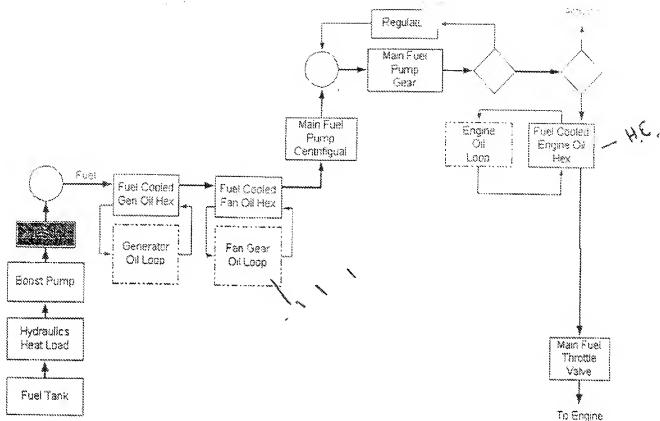


Figure 2: Example Thermal management system for a geared turbfan engine employing an FSU.

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